Dual Battery Pack Charger

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PMP - Battery Charge Management

In the current market, mobile electronic users require a second battery pack for use when AC power is not readily available. The assumption is that the packs are removable and can be at different charge (voltage) levels. Two different approaches are presented, the first using two charger ICs, and the second using a single charger IC.

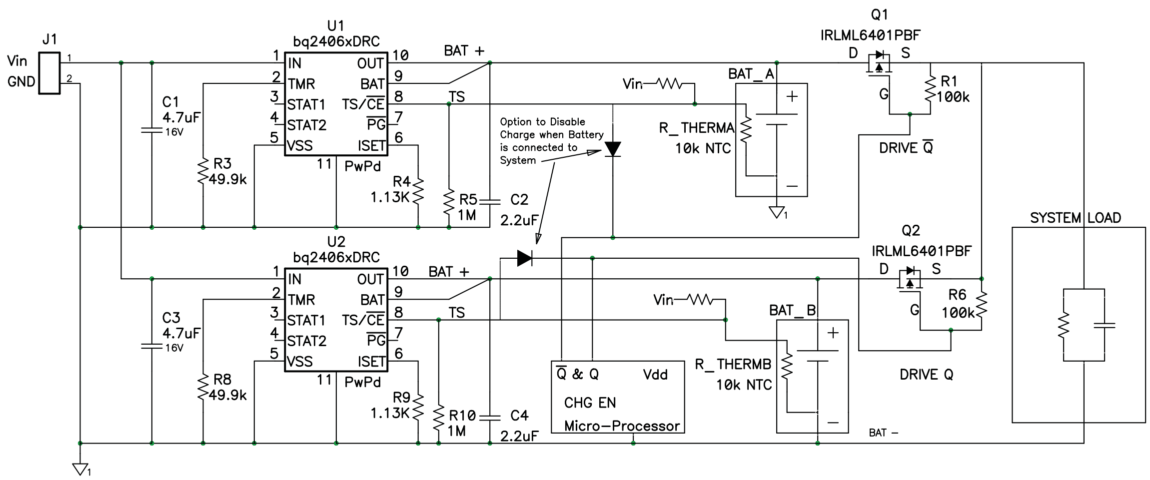

Figure 1. Dual Battery Pack Charger With Two Charger ICs

It can be difficult to decide which solution is best for the user's application. Therefore, it is important to specify the requirements for the application, and then decide which solution is the best.

1 Two Charger IC solution

The first solution, in Figure 1, is designed with two charger ICs independently charging their respective battery. A control signal, Q and $\overline{Q}$, is used to connect either Battery A or Battery B to the system Load.

This design has a selection control using only two SOT-23 p-CH FETs and two Charger ICs. The advantages of this topology are similar to a stand alone charger where little or no processor interaction is required. The pack selection control can be implemented discretely with a comparator connecting the higher voltage pack to the system. Hysteresis should be added to allow the system pack to drop no more than 0.5V below the reserve pack before swapping packs. If the reserve pack is more than 0.6V above the system pack, the current is conducted through the body diode of the reserve pack switch. There is no harm if this happens, but there is an efficiency hit and excess heat dissipation. If there is a micro-processor, it can monitor the cell voltages, and control the gates of the FET switches. Each battery pack has the cell voltage and the TS voltage monitored by its respective charger IC.

Adaptor Choices

If both chargers are designed to run at the same time, an adaptor with twice the available current is needed. To reduce costs, a lower power adaptor is used with a control signal to pull one charger's TS pin high or low, and put that charger into suspend. An open collector type signal can be used, or a diode inserted to isolate the signal when not disabling the charger, as shown in Figure 1. Connecting the pack with the largest capacity (highest voltage) to the system while charging the other pack, is recommended.

It is possible to run both chargers with a low power adaptor at the same time by letting the adaptor operate in current limit, and most of the current will go to the lower voltage battery. This may be a way to reduce heat dissipation in the charger IC. The bq2406x has an undervoltage lock-out (UVLO) voltage of ~3V, and continues to charge while the input remains above UVLO.

Swapping System Battery Pack With Reserve Pack-Transition

There is little concern about system drop-out while switching between battery packs to power the system. The control signal to turn on (pull down the gate) the FET, connecting the full cell to the system, should be in the microsecond time frame, while disconnecting the present pack may take 100µs. Therefore, there is no drop out of the system voltage, but there may be considerable shoot through current, see Figure 2. The gate capacitance is ~830pF, so a pull-up of 100k or less is recommended. This gives a time constant of ~83µs. The combined series resistance, from the output of the charger to the cell of the switcher and battery impedance, is ~250mΩ, and a potential voltage difference of 1Vmax, so there could be a 4Amax pulse for 83µs. A lower value pull-up resistor reduces this duration, and setting the comparator’s hysteresis to ~0.5V reduces the amplitude by half the maximum. The peak current for the short duration is not a safety issue, but can be a noise issue, depending on the layout and application. The other solution uses just one charger, but more selection FETS.

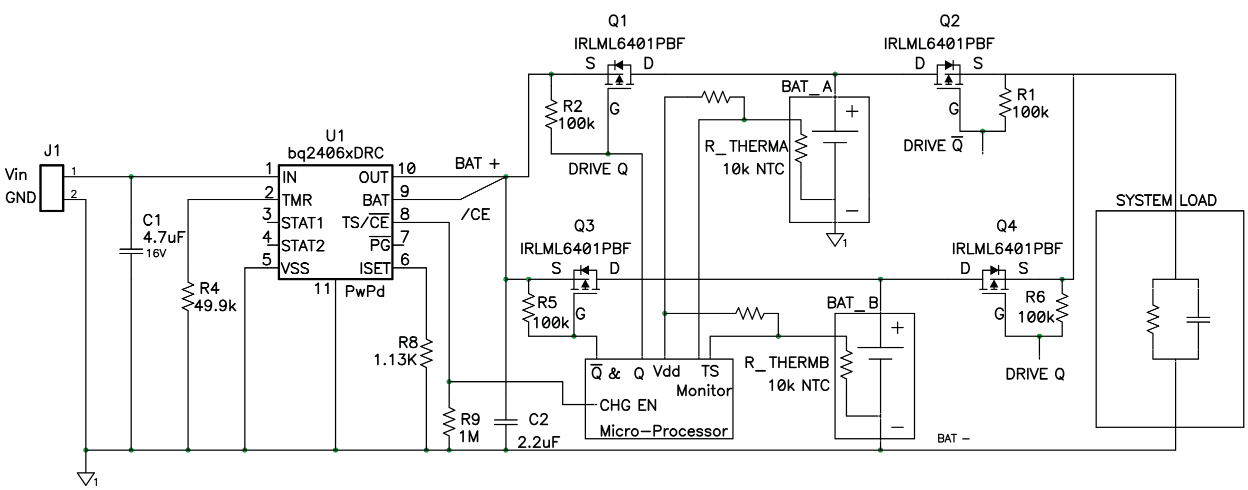

Figure 2. Dual Battery Pack Charger With Single Charger IC

2 One Charger IC Solution

The user assumes that the design in Figure 2 is the low cost solution, but this may not be true when the total solution cost is analyzed. This design uses twice the p-ch FETs and control circuit, and requires more control signals from the processor. The layout area may also be larger.

This design does not require a larger adaptor since there is only one charger IC, and only one battery is connected to the charger at a time. The recommended solution is to charge the battery that is not connected to the system, and switch packs when the charged one becomes full (charge terminates). The micro-processor should also toggle the charge enable pin after switching battery packs to initiate a new charge. Since this design uses a single charger, there is only one feedback pin for BAT and TS. The Battery voltage line is switched, but the TS line is not; therefore, it is necessary to switch the TS line or have the micro-processor monitor the TS lines, and control the charge enable line to enable charge or suspend charge.

Single Battery-to-System FET to Simplify Design

To minimize the number of FETs, in both designs, a single FET is used in series between the system and each battery. They are arranged such that one battery can not discharge into another battery, but each battery can provide current to the system via the body diode. If the reserve battery is greater than 0.6V above the system battery, it delivers current through the body diode. If designed correctly, this should not happen, and should not be a safety issue. If for some reason this is not allowed, another FET can be inserted in series, with gates tied together, such that the FET pair has the body diodes in different directions preventing conduction in either direction unless they are turned on.

Other Control Options

The spare battery is charged and then switched to the system after termination or when 0.5V higher in voltage than the system battery, eventually generating two full batteries. Another option to consider is when both batteries are approximately at the same voltage; turn on all the FETs to put both batteries in parallel, charging with one or both chargers. Another option to consider is a long life healthy mode implemented by switching out a battery from the charger to the system once it reaches 4.1V, especially at high temperatures.

Summary

Two different dual battery pack chargers have been presented. Both work well for most applications. The single charger design may cost less, but it can be more complicated to implement. The dual charger may require a higher current adaptor if both batteries are to be charged at the same time. Battery selection control options were discussed. A successful design starts with a good definition of the charging and system requirements. Knowing the system helps tailor the design to meet the requirements.

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